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NATIONAL DAM SAFETY PROGRAM, LOCH LEONARD DAM (MO 20309), MISSO--ETC(U)  
AUG 79 J M HEALY, G WERTEPNY, S L BRADY DACW43-79-C-0070

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## MISSOURI-KANSAS CITY BASIN

AD A105351

LOCH LEONARD DAM  
CASS COUNTY, MISSOURI  
MO 20309

# PHASE 1 INSPECTION REPORT NATIONAL DAM SAFETY PROGRAM



United States Army  
Corps of Engineers

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**St. Louis District**

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PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

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FOR: STATE OF MISSOURI

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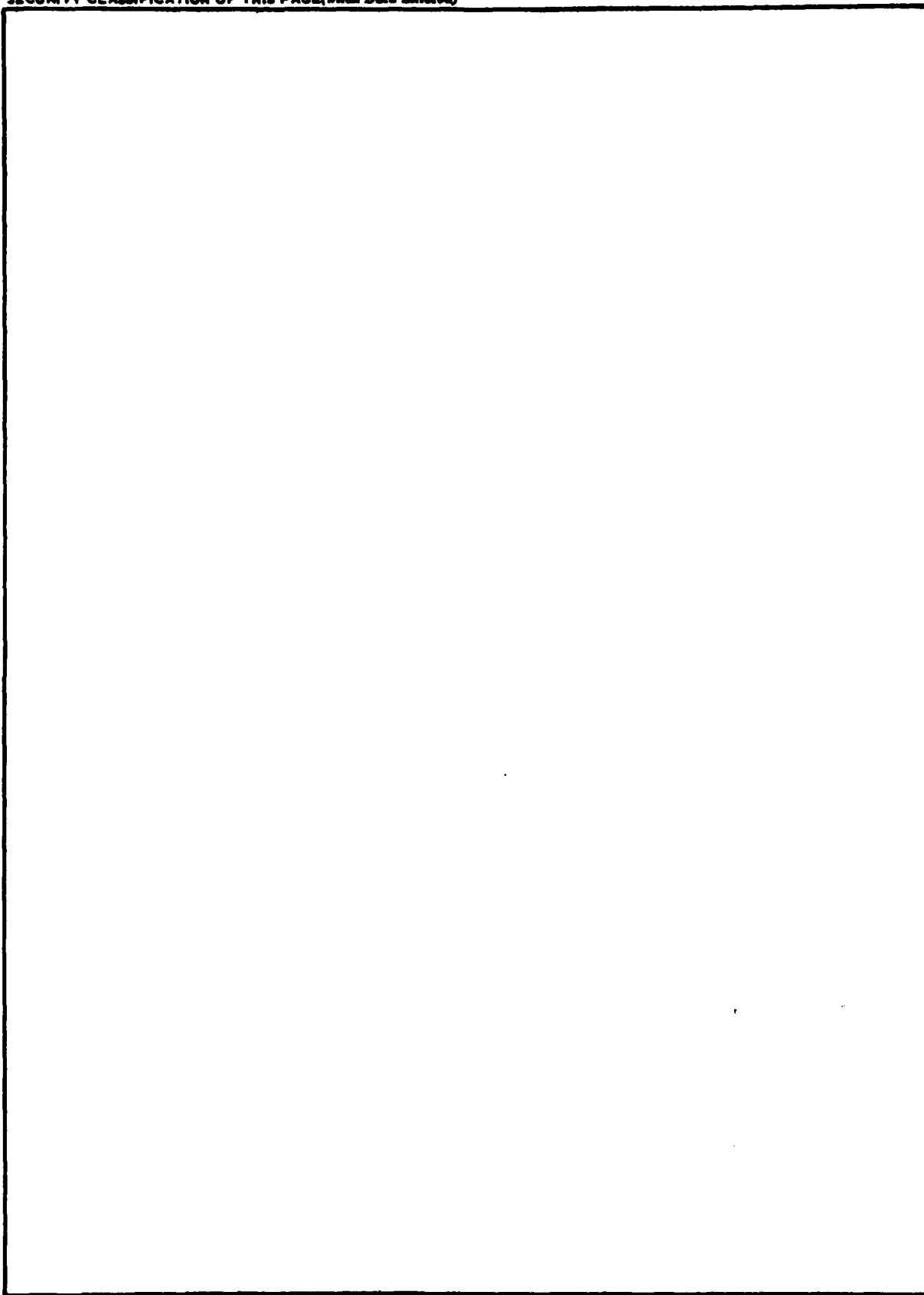
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DEPARTMENT OF THE ARMY  
ST. LOUIS DISTRICT, CORPS OF ENGINEERS  
210 NORTH 12TH STREET  
ST. LOUIS, MISSOURI 63101

IN REPLY REFER TO

SUBJECT: Loch Leonard Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Loch Leonard Dam:

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

- 1) Spillway will not pass 50 percent of the Probable Maximum Flood.
- 2) Overtopping could result in dam failure.
- 3) Dam failure significantly increases the hazard to loss of life downstream.

SUBMITTED BY:

**SIGNED**

Chief, Engineering Division

19 SEP 1979

Date

APPROVED BY:

**SIGNED**

Colonel, CE, District Engineer

19 SEP 1979

Date

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LOCH LEONARD DAM  
CASS COUNTY, MISSOURI  
MISSOURI INVENTORY NO. 20309

6 PHASE I INSPECTION REPORT  
NATIONAL DAM SAFETY PROGRAM.

Loch Leonard Dam (MO 20309)  
Missouri - Kansas City Basin, Cass County,  
Missouri. Phase I Inspection Report.

Prepared by

Anderson Engineering, Inc. Springfield, Missouri  
Hanson Engineers, Inc., Springfield, Illinois

9 Final rept.,

15 DACW 43-79-C-0070

10 John M. /Healy Gene /Wertepny  
Steven L. /Brady John /Renner Tom /Beckley

Under Direction of  
St. Louis District, Corps of Engineers

For  
Governor of Missouri

1258

Aug 1979

PHASE I REPORT  
NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Loch Leonard Dam
State Located:	Missouri
County Located:	Cass County
Stream:	Tributary of Wilson Creek
Date of Inspection:	21 June 1979

Loch Leonard Dam was inspected by an interdisciplinary team of engineers from Anderson Engineering, Inc. of Springfield, Missouri and Hanson Engineers, Inc. of Springfield, Illinois. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

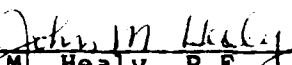
The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers, and they have been developed with the help of several Federal and State agencies, professional engineering organizations, and private engineers. Based on these guidelines, the St. Louis District Corps of Engineers has determined that this dam is in the high hazard potential classification, which means that loss of life and appreciable property loss could occur if the dam fails. The estimated damage zone extends approximately one mile downstream of the dam. Located within this zone are 5 dwellings, 4 individual structures, and 2 railroads. Upstream 0.35 miles is Kellogg Lake containing 4 acres and several small lakes above Kellogg Lake. The dam is in the small size classification, since it is less than 40 ft. high and the maximum storage capacity is greater than 50 acre-ft. but less than 1000 acre-ft.


Our inspection and evaluation indicates that the combined spillways do not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The combined spillways will pass 9 percent of the Probable Maximum Flood without overtopping. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The guidelines require that a dam of


small size with a high downstream hazard potential pass 50 to 100 percent of the PMF. Considering (1) the existence of a dam upstream, (2) that the height of the dam is only 19 feet and (3) that the maximum storage is 191 acre-ft., 50 percent of the PMF has been determined to be the appropriate spillway design flood. The 100-year frequency flood will overtop the dam. The 100-year flood is one that has a 1 percent chance of being exceeded in any given year. The 10-year frequency flood will not overtop the dam. The 10-year flood is one that has a 10 percent chance of being exceeded in any given year.


The embankment appeared to be generally in good condition. Deficiencies visually observed by the inspection team were: (1) Some brush and small trees on both faces of the dam; (2) Seepage area at the downstream toe across from Sta. 2 + 50; (3) Seepage through the embankment across from the pump station at Sta. 11 + 30; and (4) Inlet to 15 inch primary spillway pipe out of the settling basin is blocked with vegetation and debris. Another deficiency was the lack of seepage and stability analysis records.


It is recommended that the owners take the necessary action in the near future to correct the deficiencies reported herein. A detailed discussion of these deficiencies is included in the following report.

  
John M. Healy, P.E.  
Hanson Engineers, Inc.

  
Gene Wertepny, P.E.  
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Steven L. Brady, P.E.  
Anderson Engineers, P.E.

  
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Anderson Engineering, Inc.



AERIAL VIEW OF LAKE AND DAM

PHASE I INSPECTION REPORT  
NATIONAL DAM SAFETY PROGRAM

LOCH LEONARD DAM ID No. 20309

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## SECTION 1 - PROJECT INFORMATION

### 1.1 GENERAL:

#### A. Authority:

The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, District Engineer directed that a safety inspection be made of Loch Leonard Dam in Cass County, Missouri.

#### B. Purpose of Inspection:

The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and a visual inspection in order to determine if the dam poses hazards to human life or property.

#### C. Evaluation Criteria:

Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief Engineers, "Recommended Guidelines for Safety Inspection of Dams, Appendix D." These guidelines were developed with the help of several federal agencies and many state agencies, professional engineering organizations, and private engineers.

### 1.2 DESCRIPTION OF PROJECT:

#### A. Description of Dam and Appurtenances:

The Loch Leonard Dam is an earth fill structure approximately 19 ft. high and 1900 ft. long at the crest. The appurtenant works consist of: a pump station with an 8 inch discharge pipe from the lake to a Missouri Public Service Co. power plant; a pump station in the stream by the lake with one 18 inch diameter pipe to the lake and one 18 inch diameter pipe to the settling basin; a 15 inch diameter CMP from the settling basin to the stream; and a 60 inch diameter pipe between the lake and settling basin.

The only spillways associated with this dam would be the 18 inch pipe from the lake back through the pump station

to the stream and the 15 inch CMP from the settling basin to the stream. Sheet 3 of Appendix A shows a plan, profile and typical section of the embankment.

B. Location:

The dam is located in the North Central part of Cass County, Missouri on a tributary of Wilson Creek. The dam and lake are within the Pleasant Hill, Missouri 7.5 minute quadrangle sheet (Section 18, T46N, R30W - latitude 38° 47.8'; longitude 94° 16.5). Sheet 2 of Appendix A shows the general vicinity.

C. Size Classification:

With an embankment height of 19 ft. and a maximum storage capacity of approximately 191 acre-ft., the dam is in the small size category.

D. Hazard Classification:

The St. Louis District, Corps of Engineers has classified this dam as a high hazard dam. The estimated damage zone extends approximately one mile downstream of the dam. Located within this zone are 5 dwellings, 4 individual structures, and 2 railroads. Upstream .35 miles is Kellogg Lake containing 4 acres and several small lakes above Kellogg Lake.

E. Ownership:

The dam is owned by Missouri Public Service Company. The owner's address is 10700 E. 50 Highway, Raytown, Missouri 64138.

F. Purpose of the Dam:

The dam was constructed primarily to provide a source of water for the Rock Island Railroad Company. The dam is now used to provide a source of water for the Missouri Public Service Co. power plant in Pleasant Hill.

G. Design and Construction History:

No design information or plans are available. The dam was built by the railroad. Information from the present owner indicates that the dam was constructed about 1900. The material for the dam was obtained from the surrounding

hillside. A core trench through the embankment was dug along the south end of the dam 2 to 3 years ago to correct seepage through this embankment. This trench was then filled with clay and the embankment reconstructed.

#### H. Normal Operative Procedures:

Water from the lake is pumped by an 8 inch diameter pipe from the new pump station to the power plant as it is needed. The lake level is maintained by pumping water from the stream into the settling basin (or lake) via two 18 inch diameter pipes. The levels of the settling basin and the lake are equalized by the 60 inch diameter pipe. Mr. Phil Ford, an area resident, said that the lake receives only a small amount of runoff from the watershed. Mr. Ford also said that continuous pumping through the 8 inch diameter pipe to the power plant would lower the lake level at the rate of 1 inch per day.

Mr. Ford said the dam was overtopped slightly on the south embankment 4 to 5 years ago.

#### 1.3 PERTINENT DATA:

Pertinent data about the dam, appurtenant works, and reservoir are presented in the following paragraphs. Sheet 3 of Appendix A presents a plan, profile and typical section of the embankment.

##### A. Drainage Area:

The drainage area for this dam, as obtained from the U.S.G.S. quad sheet, is equal to approximately 108 acres.

##### B. Discharge at Dam Site:

- (1) All discharge at the dam site is through uncontrolled spillways.
- (2) Estimated Total Spillway Capacity at Maximum Pool (Top of Dam - El. 98.9): 18 cfs
- (3) Estimated Capacity of Primary Spillway: 18 cfs
- (4) Estimated Experienced Maximum Flood at Dam Site: 99.0 Feet.
- (5) Diversion Tunnel Low Pool Outlet at Pool Elevation: Not Applicable

- (6) Diversion Tunnel Outlet at Pool Elevation: Not Applicable
- (7) Gated Spillway Capacity at Pool Elevation: Not Applicable
- (8) Gated Spillway Capacity at Maximum Pool Elevation: Not Applicable

C. Elevations:

- (1) Top of Dam: 98.9 Feet (Low Point); 99.5 Feet (Ave.)
- (2) Principal Spillway Pipe Inverts: 97.2 Feet
- (3) Emergency Spillway Crest: Not Applicable
- (4) Principal Outlet Pipe Invert: Not Applicable
- (5) Streambed at Centerline of Dam: 82.0 Feet
- (6) Pool on Date of Inspection: 96.18 Feet
- (7) Maximum Tailwater: Unknown
- (8) Upstream Portal Invert Diversion Tunnel: Not Applicable
- (9) Downstream Portal Invert Diversion Tunnel: Not Applicable

D. Reservoir Lengths:

- (1) At Top of Dam: 1610 Feet
- (2) At Principal Spillway Pipe Inverts: 1600 Feet
- (3) At Emergency Spillway Crest: Not Applicable

E. Storage Capacities:

- (1) At Principal Spillway Pipe Inverts: 142 Acre-Feet
- (2) At Top of Dam: 191 Acre-Feet
- (3) At Emergency Spillway Crest: Not Applicable

F. Reservoir Surface Areas:

- (1) At Principal Spillway Pipe Inverts: 28 Acres
- (2) At Top of Dam: 30 Acres
- (3) At Emergency Spillway Crest: Not Applicable

G. Dam:

- (1) Type: Earth Fill
- (2) Length at Crest: 1900 Feet
- (3) Height: 19 Feet
- (4) Top Width: 5 Feet
- (5) Side Slopes: Upstream 2.4H to 1.0V; Downstream 2.1H to 1.0V
- (6) Zoning: Homogeneous - No Internal Drainage
- (7) Impervious Core: None, except for clay core in repair area on south embankment that was installed in 1978.
- (8) Cutoff: None
- (9) Grout Curtain: None

H. Diversion and Regulating Tunnel:

- (1) Type: None
- (2) Length: Not Applicable
- (3) Closure: Not Applicable
- (4) Access: Not Applicable
- (5) Regulating Facilities: Not Applicable

I. Spillway

I.1 Principal Spillway:

- (1) Location: Station 12 + 80 on main embankment and north end of settlement basin.
- (2) Type: 18 inch diameter pipe through embankment to pump

station in stream and a 15 inch CMP through settling basin to stream.

I.2 Emergency Spillway:

- (1) Location: None
- (2) Type: Not Applicable

J. Regulating Outlets:

An 8 inch diameter steel pipe located in the embankment at the pump platform used to carry water to the power plant. Flow through this pipe is present only when the pump is in operation. Mr. Phil Ford indicated that with the pump in continuous operation the lake level drops at the rate of 1 inch per 24 hour time period.

## SECTION 2 - ENGINEERING DATA

### 2.1 DESIGN:

No engineering data exists for this dam. No documented maintenance or operation data exist to our knowledge.

#### A. Surveys:

No detailed surveys have been made of the dam to our knowledge. The southwest corner of the pump platform was used as datum for our site survey (Elevation 100.00). It is estimated that this site datum corresponds to a mean sea level elevation of about 865.

#### B. Geology and Subsurface Materials:

The site is located in the Western Plains geologic region of Missouri. The Western Plains region is characterized topographically by being level to gently undulating with wide imperceptibly rising floodplains. The sedimentary rock layers exposed in the Ozarks region dip downward away from the Ozarks region and the higher and younger sedimentary deposits become the surface ledges in southwest and Western Missouri. Generally the soils in the Western Plains region are residual from limestone, shale and sandstone with some loessial cover in some areas. Pennsylvanian micaceous shale formed the parent material for the soils found in the area of the Loch Leonard Dam.

Soils in the area of the dam appear to be primarily shaley, clay silt with some gravel. The soils are primarily of the Norris soil series. The loessial thickness map (Sheet 2 of Appendix B) indicates that some areas of this region may have between 5.0 and 10.0 feet of loess cover.

The "Geologic Map of Missouri" indicates that the nearest known fault is approximately 20 miles southwest of the dam site. The Missouri Geological Survey has indicated that the faults in this area are generally considered to be inactive and have been for several hundred million years. The publication "Caves of Missouri" indicates there are no known caves in Cass County.

#### C. Foundation and Embankment Design:

No design computations are available. No information

is available of the original construction. Mr. Phil Ford, a local resident, indicated that the embankment fill is composed of materials from the surrounding hillside. The owner stated that the repair work on the south side of the embankment consisted of a core trench 12 to 15 feet in depth filled with clay obtained from on site. The core trench was approximately between Stas. 2 + 00 and 5 + 00. No internal drainage features were incorporated, nor is there any particular zoning of the embankment. No construction inspection records are available.

#### D. Hydrology and Hydraulics:

No hydrologic or hydraulic design data were obtained. Our analyses of the PMF are presented in Appendix C. These analyses were based on our field survey and observations, and estimates of areas and volumes from the U.S.G.S. quad sheet. It was concluded that the structure will pass 9 percent of the Probable Maximum Flood without overtopping. The 100-year frequency flood will overtop the dam and the 10-year frequency flood will not overtop the dam.

#### E. Structure:

The appurtenant structures consist of the 8 inch diameter pipe used to supply water to the power plant by pumping. The 18 inch diameter pipes from the stream to the settling basin and lake and the 15 inch diameter pipe from the settlement basin to the stream. The pump from the stream to the lake is protected with an anti-reversing mechanism. A 60 inch diameter pipe connects the settling basin and the lake.

#### 2.2 CONSTRUCTION:

No construction inspection data have been obtained.

#### 2.3 OPERATION AND MAINTENANCE:

Water from the lake is pumped to the power plant as needed by the new pump station through an 8 inch diameter pipe. Water level is restored by pumping from the adjacent stream to the settling basin or lake. An 18 inch pipe and a 15 inch CMP act as a primary spillway should the lake level rise above their overflow level. There is no emergency spillway associated with this dam. No operating records are known to exist for this dam. Portions of the embankment are mowed on a regular basis.

## 2.4 EVALUATION:

### A. Availability:

No engineering data, seepage or stability analyses, or construction test data were available.

### B. Adequacy:

The engineering data available were inadequate to make a detailed assessment of the design, construction, and operation. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

### C. Validity:

No valid engineering data on the design or construction of the embankment are available to our knowledge.

## SECTION 3 - VISUAL INSPECTION

### 3.1 FINDINGS:

#### A. General:

The field inspection was made on 21 June 1979. The inspection team consisted of personnel from Anderson Engineering, Inc. of Springfield, Missouri and Hanson Engineers, Inc. of Springfield, Illinois. The team members were:

John M. Healy-Hanson Engineers, Inc. (Geotechnical Engineer)  
Gene Wertepny - Hanson Engineers, Inc. (Hydraulic Engineer)  
Steven L. Brady - Anderson Engineering, Inc. (Civil Engineer)  
Tom Beckley - Anderson Engineering, Inc. (Civil Engineer)  
John Renner - Anderson Engineering, Inc. (Civil Engineer)

#### B. Dam:

The dam appears to be generally in good condition. No sloughing of the embankment was noted. The dam was constructed on an irregular curve concave to the downstream direction. The dam is fairly level across the crest, and no surface cracking or unusual movement was obvious. The settling basin embankment appeared to be constructed of the same soils as the main dam. The crest of the basin embankment was approximately 12 feet wide and varied from 99.6 feet to 101.8 feet in elevation. The slope of the front face was irregular varying from 2H:IV to considerably steeper. The back slope was approximately 3H:IV or flatter. The back face had a lot of tree and brush growth. A 15 inch diameter steel pipe extends from the settling basin through the embankment discharging into the stream.

Light brush and small trees were noted on the downstream face near the north abutment. Heavy brush and weed growth was present on the downstream face near the south abutment. Numerous small trees and brush were noted on both faces of the settlement basin around its perimeter.

The front face of the dam has riprap and concrete slope protections extending to within 1 foot of the crest. The riprap and concrete appeared to be reasonably intact. No animal burrows were noted.

Seepage at the approximate rate of 1 gallon per minute was observed at the toe of the slope at Sta. 2 + 50. A con-

siderable growth of reeds and cattails were observed in this area. Less than 1 gallon per minute of seepage was coming through the embankment across from the new pump platform (Sta. 11 + 30) near a power pole. The seepage appeared to be flowing in a channel along a buried electrical cable through the embankment. No soil appeared to be transported in either seepage area.

No instrumentation (monuments, piezometers, etc.) was observed.

### C. Appurtenant Structures:

#### C.1 Primary Spillway:

The 18 inch diameter steel pipe between the lake and the stream via the pump station appear to be in good condition. As the inlet is usually above normal pool elevation and the pipe extends 10 feet into the lake. Maintenance around the pipe should be minimal. The discharge is through the pump and down the vertical suction pipe into the river.

The inlet to the 15 inch diameter CMP pipe between the settlement basin and the stream is partially blocked by debris and vegetation which should be removed. The riprap at the inlet appears to be in good condition. The outlet channel is approximately 4 feet wide and lined with trees and heavy brush.

#### C.2 Emergency Spillway: None

### D. Reservoir:

The slopes adjacent to the lake are rolling, and no sloughing or serious erosion was noted. The watershed is basically wooded with some development. Considerable sedimentation has occurred. Mr. Phil Ford, a local resident, stated that the lake had filled in 3 to 4 feet in the past 25 years.

### E. Downstream Channel:

The downstream channel is a tree lined stream. A concrete check dam (5 to 6 feet high) is across the stream approximately opposite the new pump station in the lake. The city of Pleasant Hill pumps water from this area of the stream to a water treatment plant.

### 3.2 EVALUATION:

The trees and brush on the dam are potential seepage hazards and encourage animal burrows. The debris and vegetation at the settling basin spillway inlet pipe is also a deficiency. The two seepage areas plus the deficiencies above should be investigated by an engineer experienced in the design and construction of dams. The seepage area through the embankment across from the new pump station (Sta. 11 + 30) is especially serious.

Photographs of the dam, appurtenant structures, and the reservoir are presented in Appendix D.

## SECTION 4 - OPERATIONAL PROCEDURES

### 4.1 PROCEDURES:

The controlled outlet works for this dam consist of the 8 inch diameter pressure pipe to the power plant. The spillway pipes which are above normal pool level are uncontrolled. The pool level is principally controlled by pumping in and out of the lake and by rainfall, runoff and evaporation.

### 4.2 MAINTENANCE OF DAM:

The owner indicated that the area is mowed on a periodic basis.

### 4.3 MAINTENANCE OF OPERATING FACILITIES:

The two pump stations appear to be in good condition. No maintenance records for the equipment are available. The equipment is owned by the Missouri Public Service Co.

### 4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT:

The inspection team is unaware of any existing warning system for this dam.

### 4.5 EVALUATION:

The trees and brush on the dam are potential seepage hazards and encourage animal burrows. The debris and vegetation at the settling basin spillway inlet pipe is also a deficiency. The seepage area at Sta. 2 + 50 at the toe and Sta. 11 + 30 on the downstream face should be investigated by an engineer experienced in the design and construction of dams. Remedial measures will be required. Subsequently, these areas should be inspected periodically to detect any further seepage.

## SECTION 5 - HYDRAULIC/HYDROLOGIC

### 5.1 EVALUATION OF FEATURES:

#### A. & B. Design and Experience Data:

The hydraulic and hydrologic analyses were based on: (1) a field check of spillway dimensions and embankment elevations; and (2) an estimate of the pool and drainage areas from the U.S.G.S. quad sheet. No previous hydraulic or hydrologic studies were obtained. Our hydrologic and hydraulic analyses using U.S. Army Corps of Engineers guidelines appear in Appendix C.

#### C. Visual Observations:

The inlet to the 15 inch primary spillway pipe between the settlement basin and the stream should be cleared of vegetation and debris.

#### D. Overtopping Potential:

Based on the hydrologic and hydraulic analysis presented in Appendix C, the combined spillways will pass 9 percent of the Probable Maximum Flood. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The recommended guidelines from the Department of the Army, Office of the Chief Engineers, require that this structure (small size with high downstream potential pass 50 percent to 100 percent of the PMF, without overtopping. Considering (1) the existence of a dam upstream, (2) that the height of the dam is only 19 feet, and (3) that the maximum storage is 191 acre feet, 50 percent of the PMF has been determined to be the appropriate spillway design flood. The structure will not pass a 100-year frequency flood without overtopping. The structure will pass a 10-year frequency flood.

The routing of 50 percent of the PMF through the spillways and dam indicate that the dam will be overtopped by 0.57 ft. at elevation 99.47. The duration of the overtopping will be 12.08 hours and the maximum outflow will be 2471 cfs. The maximum discharge capacity of the spillway is 18 cfs. Overtopping of an earthen embankment could cause serious erosion and could possibly lead to failure of the structure.

## SECTION 6 - STRUCTURAL STABILITY

### 6.1 EVALUATION OF STRUCTURAL STABILITY:

#### A. Visual Observations:

Visual observations which could adversely affect the structural stability of this dam are discussed in Sections 3.1B and 3.2.

#### B. Design and Construction Data:

No design and construction data for the foundation and embankment were available. Seepage and stability analyses comparable to the requirements of the guidelines were not available, which constitutes a deficiency which should be rectified.

#### C. Operating Records:

No operating records have been obtained.

#### D. Post-Construction Changes:

The new pump station was built in 1978 as a result of severe seepage and piping along pipes through the west embankment to an old pump station located on the downstream side of the dam near Sta. 12 + 00. The old station was torn down and the pipes removed from the embankment. The new pump station was built and the embankment restored. A core trench along the south embankment, approximately between Stas. 2 + 00 and 5 + 00, was built 2 to 3 years ago in an attempt to cut off seepage through the embankment. The seepage on the day of inspection at the toe of the embankment in this area was approximately one gallon per minute. The seepage prior to the installation of the core trench was greater than the present flow. This information was supplied by Mr. Barry of the Missouri Public Service Co. No other changes are known by the inspection team.

#### E. Seismic Stability:

The structure is located in seismic zone 1. An earthquake of this magnitude would not generally be expected to cause severe structural damage to a well constructed earth dam of this size. However, it is recommended that the prescribed seismic loading for this zone be applied in stability analyses for this dam.

## SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

### 7.1 DAM ASSESSMENT:

This Phase I inspection and evaluation should not be considered as being comprehensive since the scope of work contracted for is far less detailed than would be required for an in-depth evaluation of dams. Latent deficiencies, which might be detected by a totally comprehensive investigation, could exist.

#### A. Safety:

The embankment is generally in good condition. Several items were noted during the visual inspection which should be investigated further, corrected or controlled. These items are: (1) brush and small tree growth on both faces of the dam; (2) seepage area at the downstream toe across from Sta. 2 + 50; (3) seepage through the embankment across from the pump station at Sta. 11 + 30; and (4) inlet to 15 inch primary spillway pipe out of the settling basin is blocked with vegetation.

The dam will be overtopped by flows in excess of 9 percent of the Probable Maximum Flood. Overtopping of an earthen embankment could cause serious erosion and could possibly lead to failure of the structure.

#### B. Adequacy of Information:

The conclusions in this report were based on review of the information listed in Section 2.1, the performance history as related by others, and visual observation of external conditions. The inspection team considers that these data are sufficient to support the conclusions herein. Seepage and stability analyses comparable to the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

#### C. Urgency:

The items recommended in paragraph 7.2 A should be pursued on a high priority basis. If the deficiencies listed in paragraph A are not corrected, and if good maintenance is not provided, the embankment condition will continue to deteriorate and possibly could become serious in the future. Priority should be given to increasing the size of the spillway.

#### D. Necessity for Phase II:

Based on the result of the Phase I inspection, no Phase II inspection is recommended.

#### E. Seismic Stability:

The structure is located in seismic zone 1. An earthquake of this magnitude would not generally be expected to cause severe structural damage to a well constructed earth dam of this size. However, it is recommended that the prescribed seismic loading for this zone be applied in any stability analyses performed for this dam.

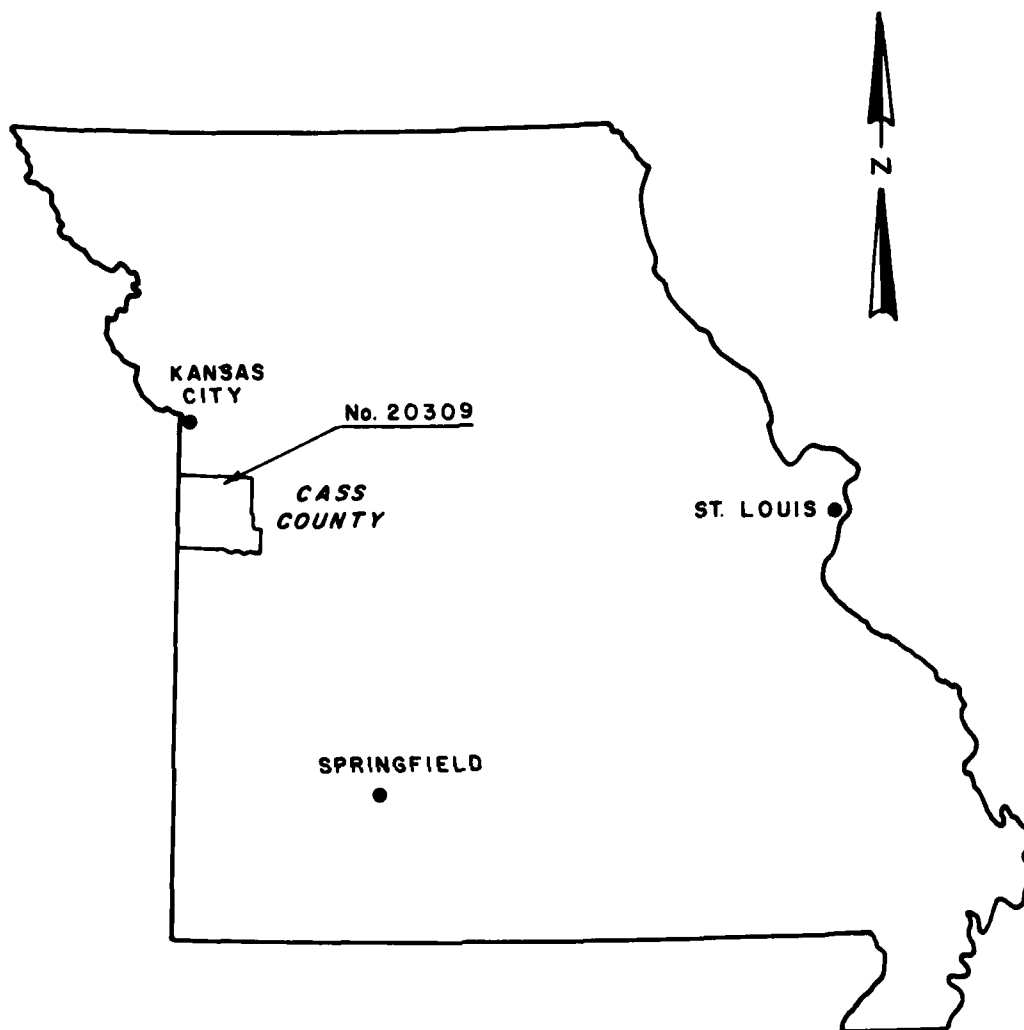
#### 7.2 REMEDIAL MEASURES:

The following remedial measures and maintenance procedures are recommended. All remedial measures should be performed under the guidance of a professional engineer experienced in the design and construction of dams.

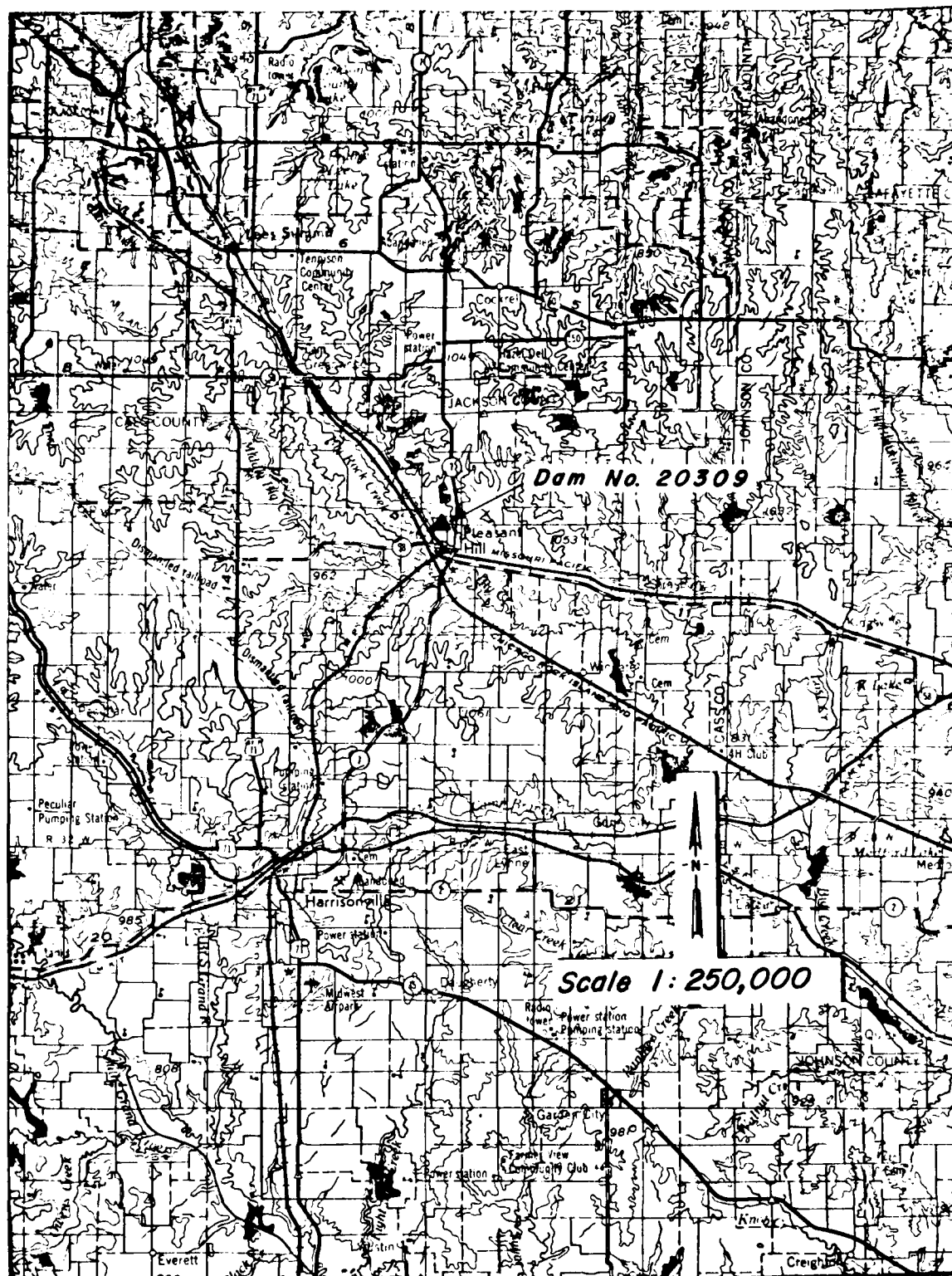
- (1) Spillway size and/or height of dam should be increased to pass 50 percent of the PMF. In either case, the spillway should be protected to prevent erosion.
- (2) Seepage and stability analyses comparable to the requirements of the recommended guidelines should be performed by a professional engineer experienced in the design and construction of dams.
- (3) Brush and tree growth should be removed from the dam and settlement basin embankment. This should be done under the guidance of a professional engineer experienced in the design and construction of dams. Indiscriminate clearing methods could jeopardize the safety of the dam.
- (4) The seepage areas at Stas. 2 + 50 and 11 + 30 on the downstream face of the dam should be investigated by a professional engineer experienced in the design and construction of dams. Remedial measures will be required. Subsequently, these areas should be inspected periodically in an effort to detect future seepage. In this event, an engineer experienced in the design and construction of dams should be contacted immediately.
- (5) The inlet to the 15 inch CMP from the settling basin to the stream should be cleared and checked on a regular basis.

- (6) A detailed inspection of the dam should be made periodically by a professional engineer experienced in the design and construction of dams.

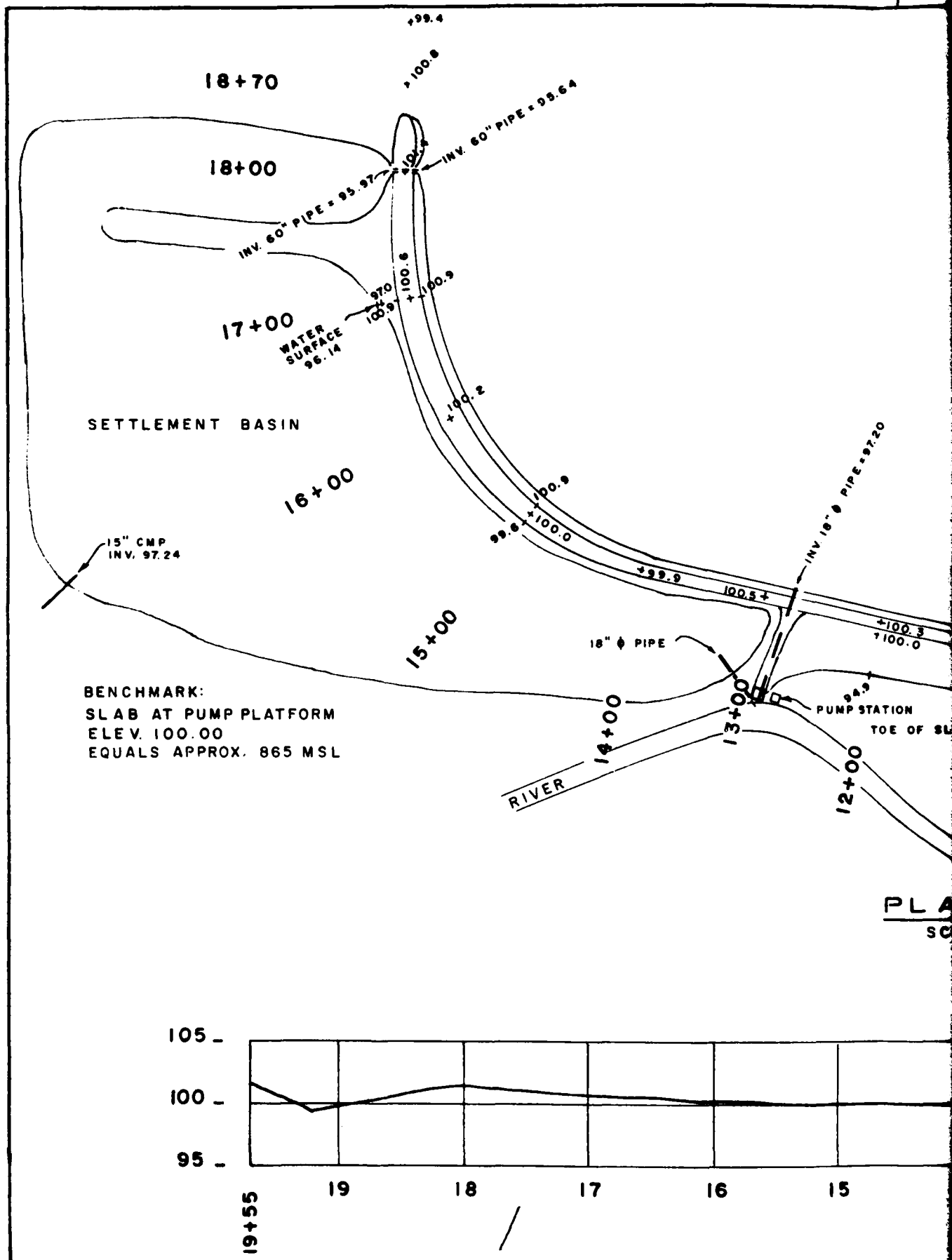
APPENDIX A

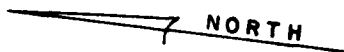


LOCATION MAP

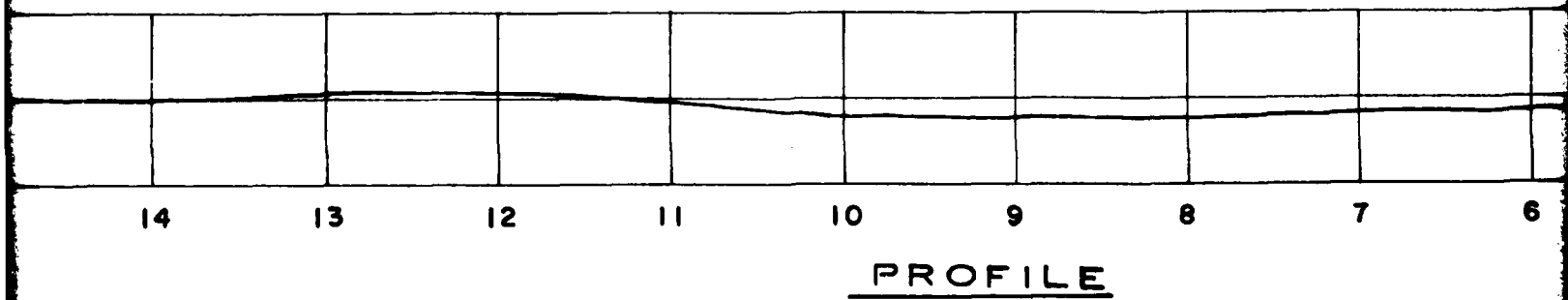
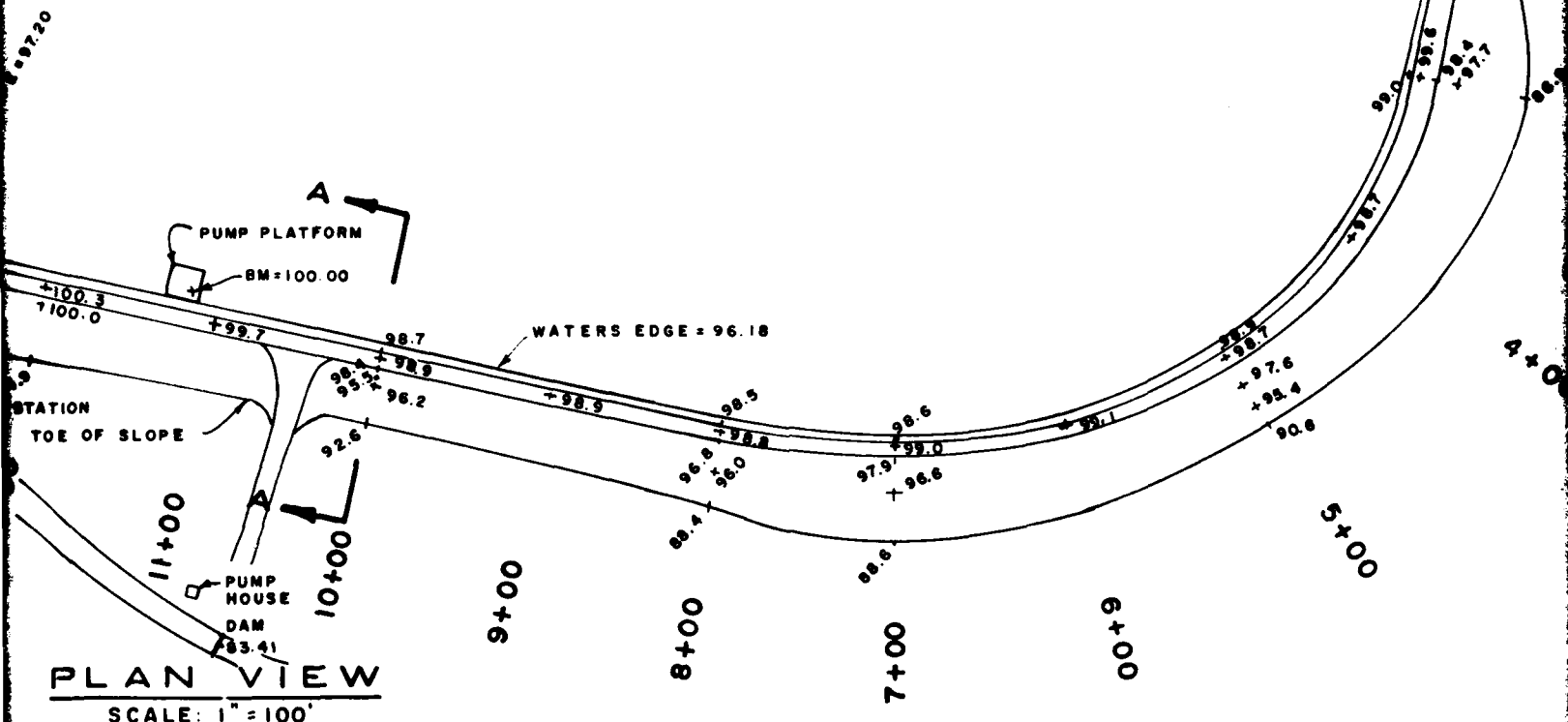


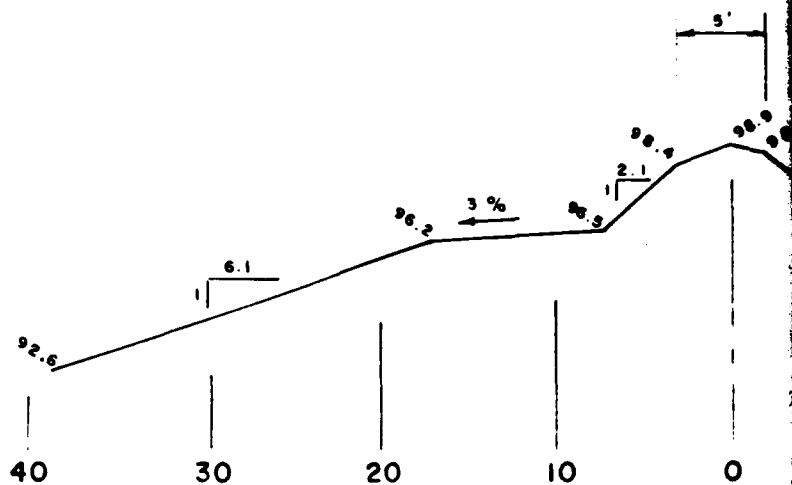
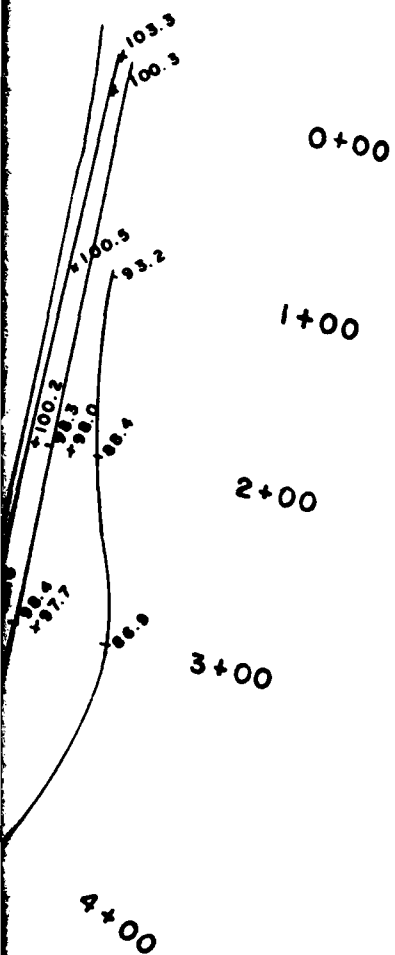
SITE VICINITY MAP



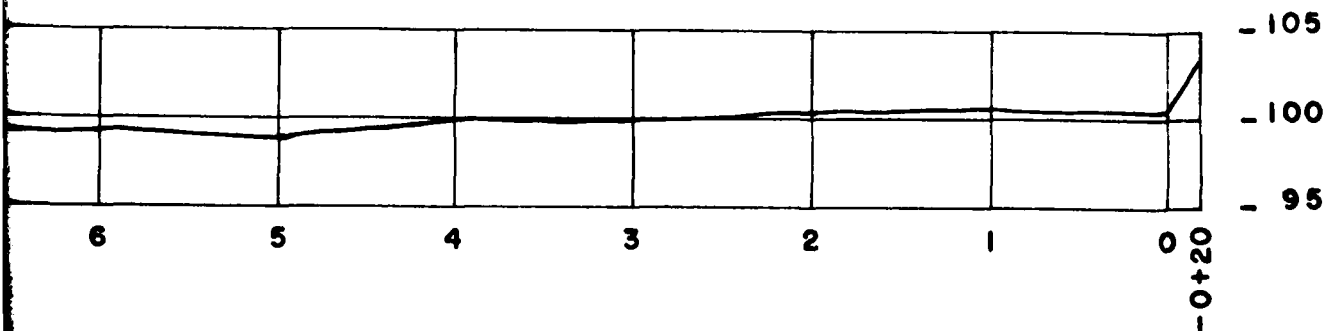


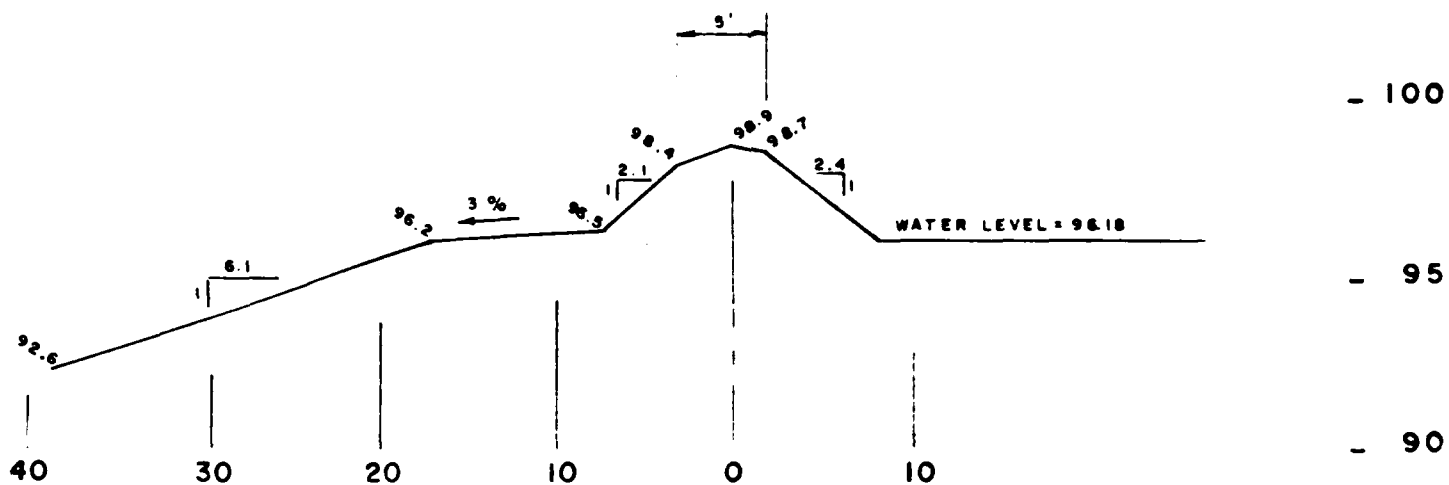
L A K E





SECTION A-A





SECTION A-A STA 10+00

Sheet 3 of Appendix A

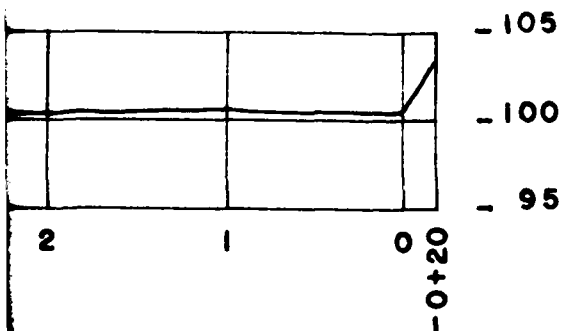
ANDERSON ENGINEERING, INC.  
730 NORTH BENTON AVENUE  
SPRINGFIELD, MISSOURI 65802

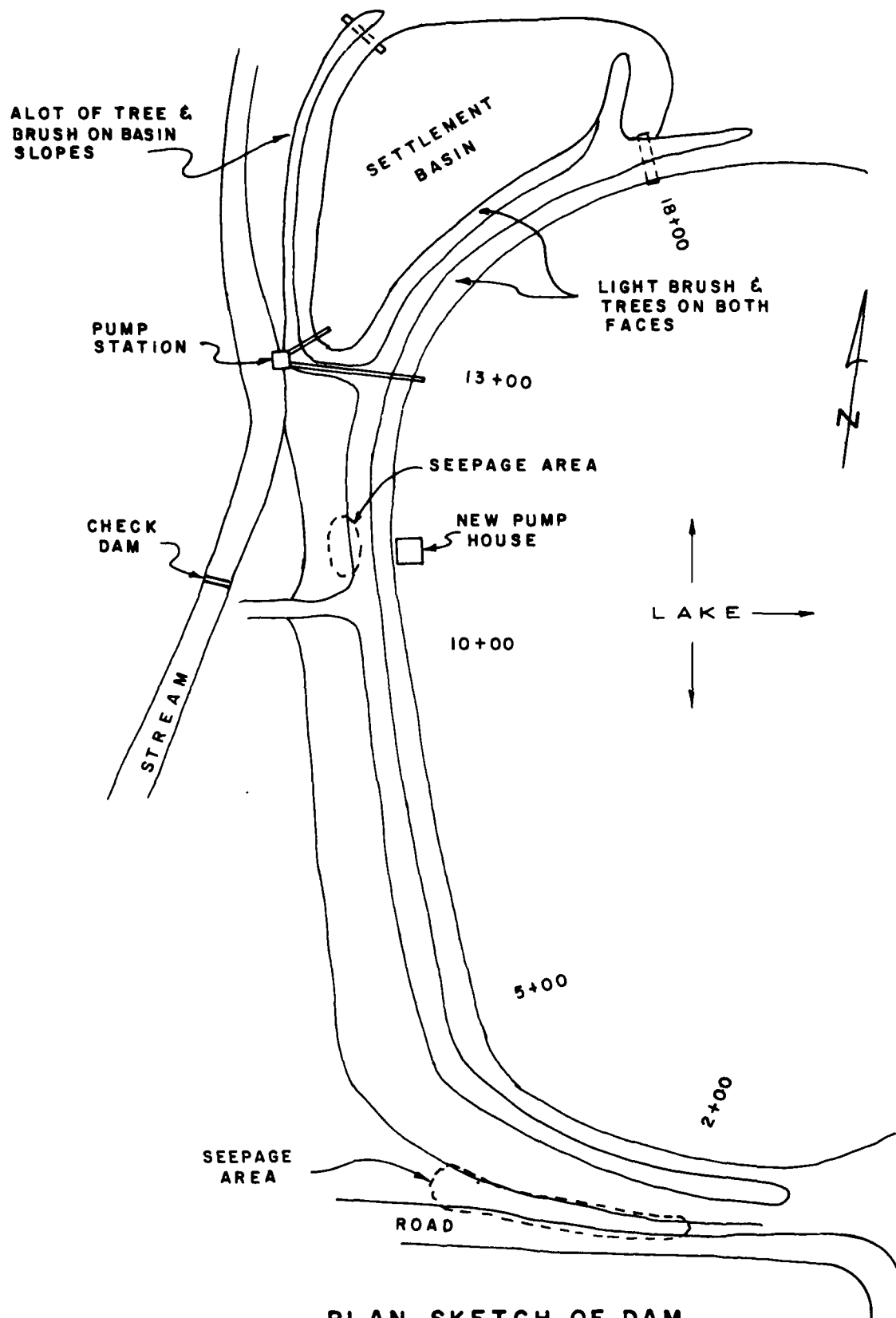
LOCH LEONARD

MO. No. 20309

PLAN & PROFILE

CASS COUNTY, MO.



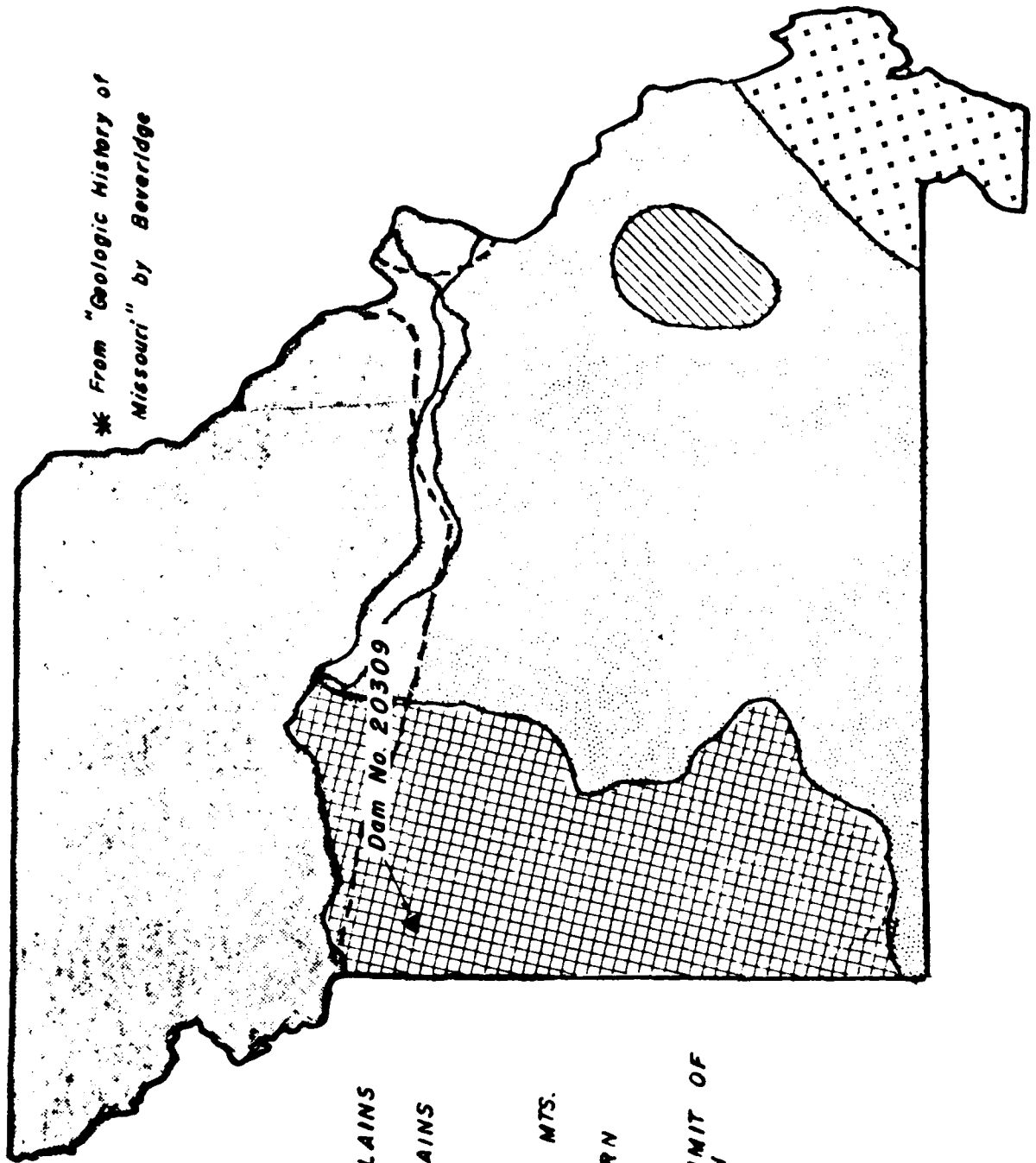


PLAN SKETCH OF DAM  
MO. 20309

APPENDIX B

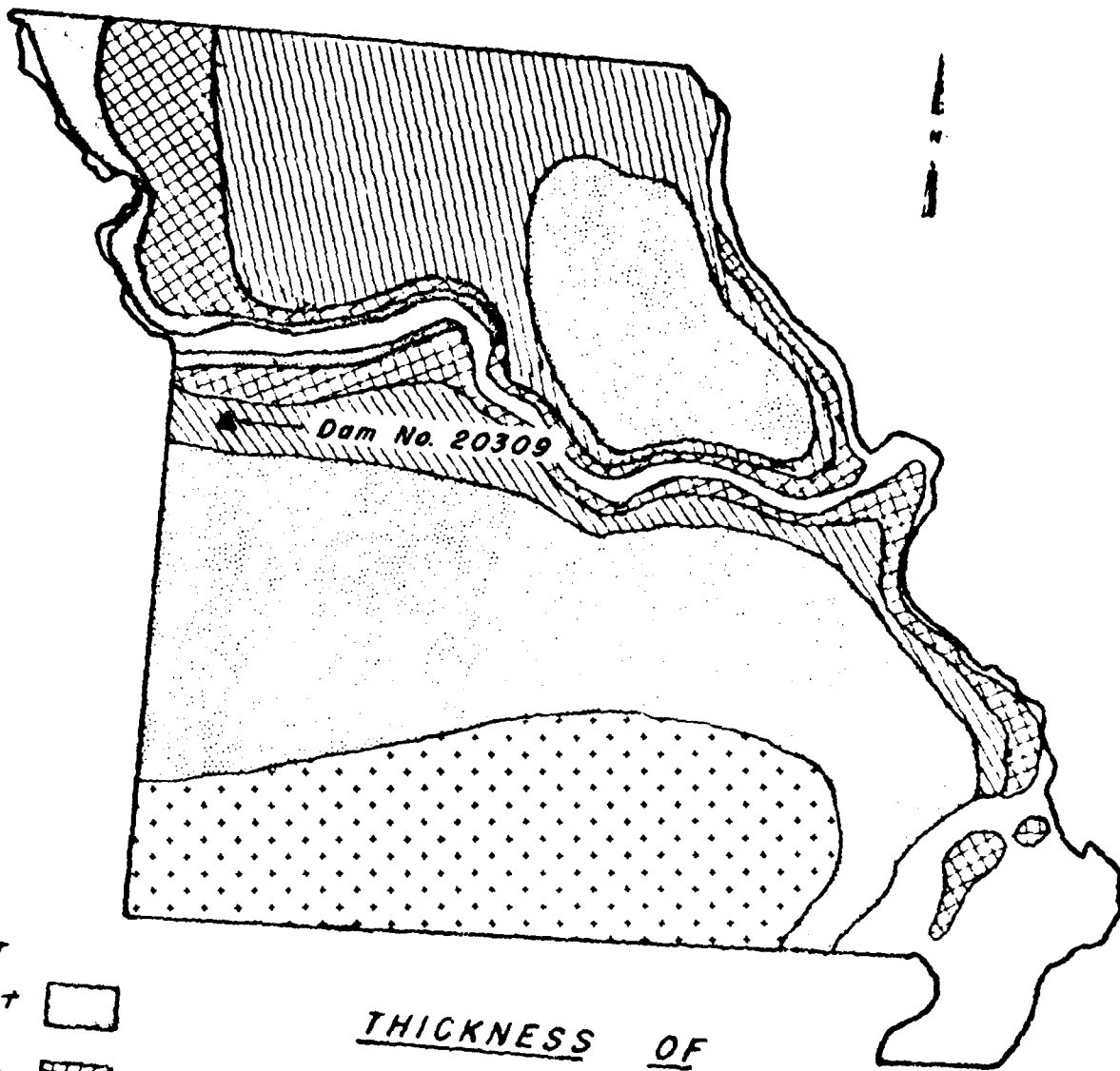
# MAJOR GEOLOGIC REGIONS OF MISSOURI






\* From "Geologic History of Missouri" by Beveridge



- GLACIATED PLAINS
- WESTERN PLAINS
- OZARKS
- ST. FRANCOIS MTS.
- SOUTHEASTERN LOWLANDS
- SOUTHERN LIMIT OF GLACIATION

\* From "Soils of Missouri"



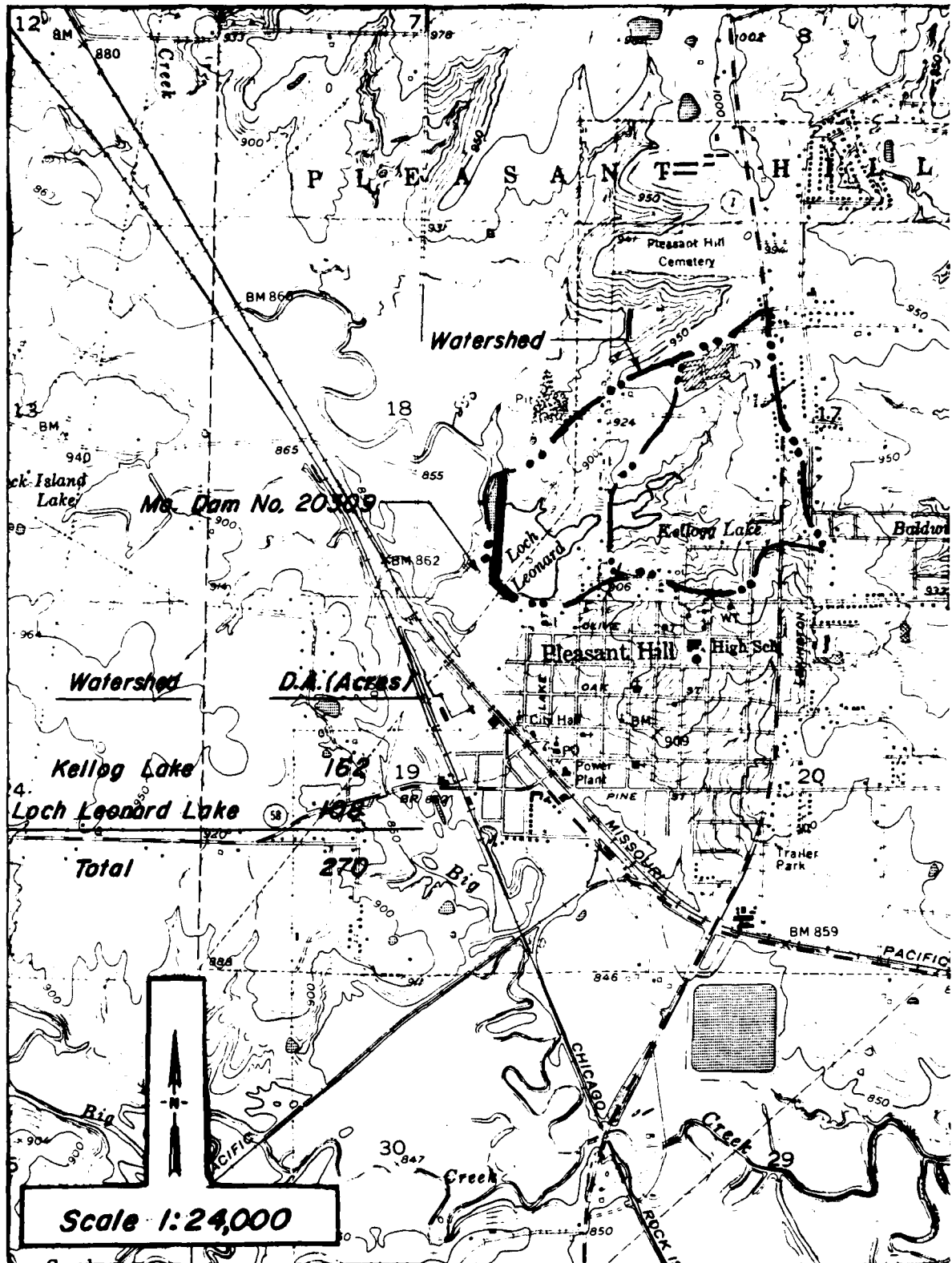
<u>FEET</u>	
20+	
10-20	
5-10	
2.5-5	
2.5-	

THICKNESS OF  
LOESSIAL DEPOSITS

SHEET 2 OF APPENDIX B

APPENDIX C

Pleasant Hill 7.5' Quad



LAKE AND WATERSHED MAP

## HYDRAULICS AND HYDROLOGIC DATA

Design Data: From Field Measurements and Computations

Experience Data: No records are available. Mr. Phil Ford, a local resident, said the dam was overtopped slightly on the south embankment 4 to 5 years ago. On the day of inspection there was no indication of high water marks or overtopping.

Visual Inspection: At the time of inspection, the pool level was approximately 1.0 feet below normal pool.

Overtopping Potential: Flood routings were performed to determine the overtopping potential. The watershed and the reservoir surface areas were obtained by a planimeter from the U.S.G.S. Pleasant Hill, Missouri 7.5 minute quadrangle map. The storage volume was developed from this data. A 5 minute interval unit graph was developed for this watershed, which resulted in a peak inflow of 549 c.f.s. and a time to peak of 9 minutes. Application of the probable maximum precipitation minus losses results in a flood hydrograph peak inflow of 5106 c.f.s. Rainfall distribution for the 24 hour storm was according to EM 11102-1411.

Based on our analyses, the combined spillways will pass 9 percent of the Probable Maximum Flood (PMF). The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The recommended guidelines from the Department of the Army, Office of the Chief of Engineers, require that the structure (small size with high downstream hazard potential) pass 50 to 100 percent of the PMF, without overtopping. Considering (1) the existence of a dam upstream (2) that the height of the dam is only 19 feet and (3) that the maximum storage is 191 acre feet, 50 percent of the PMF has been determined to be the appropriate spillway design flood.

Kellogg Dam exists upstream of Loch Leonard Dam. The dam is an earthen embankment 350 feet long. The low point of the embankment was 118.48 feet. A concrete box culvert through the embankment measured 12.5 feet wide by 5.5 feet high (inside dimensions). A 24 foot long concrete wall control section just upstream of the box culvert had an elevation of 114.8. The water level on Kellogg Lake was 114.48 on the day of inspection. To obtain more realistic results

of the flood routing studies, the PMF was considered acting simultaneously over the entire watershed area of the two dams. First, the PMF was routed through Kellogg Lake and spillway (See lake and watershed map, Sheet 1 Appendix C) then the outflow hydrograph from this dam was combined with the inflow hydrograph from the watershed of the Loch Leonard Dam and routed through the reservoir and spillway structure. The same procedure was used for the routing for the 100-year frequency flood event. The flood routing studies were made using the HEC-I Dam Safety Version Program.

The routing of 50 percent of the PMF through the spillway and dam indicates that the dam will be overtopped by 0.57 ft. at elevation 99.47. The duration of the overtopping will be 12.08 hours, and the maximum outflow will be 2471 c.f.s. The maximum discharge capacity of the combined spillways is 18 c.f.s. Analysis of the data indicates that the 100-year frequency flood will overtop the dam. The routing of the 100-year frequency flood indicates that the dam will be overtopped by 0.11 feet at elevation 99.01 feet. The duration of the overtopping will be 11.17 hours, and the maximum outflow will be 216 c.f.s. Overtopping of an earthen embankment could cause serious erosion and could possibly lead to failure of the structure.

#### OVERTOPPING ANALYSIS FOR LOCH LEONARD DAM

##### INPUT PARAMETERS

1. Unit Hydrograph - SCS Dimensionless - Flood Hydrograph Package (HEC-1); Dam Safety Version Was Used.  
Hydraulic Inputs Are as Follows:
  - a. Twenty-four Hour Rainfall of 25 Inches for 200 Square Miles - All Season Envelope
  - b. Drainage Area = 108 Acres; = 0.17 Square Miles
  - c. Travel Time of Runoff 0.18 Hrs.; Lag Time 0.11 Hrs.
  - d. Soil Conservation Service Soil Group C
  - e. Soil Conservation Service Runoff Curve No. 85  
(AMC III)
  - f. Proportion of Drainage Basin Impervious 0.27

For the 100-year flood, the soil conservation service runoff curve No. 70 (AMC II) was used and a 24 hour rainfall of 7.7 inches. The Warsaw, Missouri rainfall distribution for 1.00 square mile drainage area was supplied by the St. Louis District U. S. Army Corps.

2. Spillways

a. Primary Spillway: one 18" and one 15" steel pipe with flowline elevation 97.2

b. Emergency Spillway:

Length -- ft.; Side Slopes --; C = --

c. Dam Overflow

Length 1900 Ft.; Crest Elev. 98.9; C = 3.0

3. Spillway and Dam Rating:

Curve Prepared by Hanson Engineers. Data Provided To Computer on Y4 and Y5 Cards.

Note: Time of Concentration From Equation  $T_c = \frac{(11.9 L^3)^{.385}}{(H)^{.385}}$

California Culvert Practice, California Highways and Public Works, Sept. 1942.

Sheet 4 Appendix C

\* Similar data was developed for the upper (Kellogg Lake).

### SUMMARY OF DAM SAFETY ANALYSIS

1. Unit Hydrograph
  - a. Peak - 549 c.f.s.
  - b. Time to Peak 9 Min.
2. Flood Routings Were Computed by the Modified Puls Method
  - a. Peak Inflow  
100-year 734 c.f.s.; 50% PMF 2471 c.f.s.; 100% PMF 5106 c.f.s.
  - b. Peak Elevation  
100-year 99.01 c.f.s.; 50% PMF 99.47; 100% PMF 99.83
  - c. Portion of PMF That Will Reach Top of Dam  
9%; Top of Dam Elev. 98.9 Ft.
3. Computer Input and Output Data are shown on the following sheets of this Appendix.

A OVERTOPPING ANALYSIS FOR LOCH LEONARD DAM ( # 9 )  
A STATE ID NO. 20309 CO. NO. 037 CO. NAME CASS  
A HANSON ENGINEERS INC. DAM SAFETY INSPECTION JOB # 79511

B 300 5  
B1 5  
J 1 8 1  
J1 .05 .10 .15 .20 .30 .50 .75 1.0  
K 0 1 3 1  
K1 INFLOW HYDROGRAPH COMPUTATION FROM UPSTREAM KELLOGG LAKE  
M 1 2 0.25 0.25 1 1  
P 0 25 102 120 130  
T -1 -85 0.09

W2 0.17 0.10  
X 0 -.1 2  
K 1 2 0 4 1  
K1 RESERVOIR ROUTING BY MODIFIED PULS AT DAM SITE (KELLOGG LAKE)  
Y 1 1

Y1 1 28.8 -1  
Y4 114.5 115.5 116.5 117.5 118.5 119.5 120.5 121.5  
Y5 0 37 99 186 288 450 504 600  
\$A 0 5 9  
\$E 97.2 114.5 120  
\$\$ 114.5  
\$D 118.5 3.0 1.5 370

K 0 3 3 1  
K1 INFLOW HYDROGRAPH COMPUTATION FOR LOCH LEONARD DAM  
M 1 2 0.17 0.17 1 1  
P 0 25 102 120 130  
T -1 -85 0.27

W2 0.18 0.10  
X 0 -.1 2  
K 2 3 0 3 1  
K1 COMBINE ROUTING AND LOCAL INFLOW AT LOCH LEONARD DAM  
K 1 4 0 4 1

K1 RESERVOIR ROUTING BY MODIFIED PULS AT LOCH LEONARD DAM  
Y 1 1  
Y1 1 142 -1  
Y4 97.2 99 100 102 103  
Y5 0 18 26 40 42  
\$A 0 28 30 31.3  
\$E 82 97.2 98.9 100  
\$\$ 97.2  
\$D 98.9 3.0 1.5 1900  
K 99

P.M.F. INPUT DATA

SHEET 6 APPENDIX C

\*\*\*\*\*

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS  
 FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)  
 AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS							
				RATIO 1	RATIO 2	RATIO 3	RATIO 4	RATIO 5	RATIO 6	RATIO 7	RATIO 8
				0.05	0.10	0.15	0.20	0.30	0.50	0.75	1.00
HYDROGRAPH AT	1	0.25	1	174.	348.	522.	696.	1044.	1740.	2611.	3481.
	(	0.65)	(	4.93)	9.86)	14.78)	19.71)	29.57)	49.28)	73.92)	98.57)
ROUTED TO	2	0.25	1	52.	118.	187.	259.	718.	1538.	2366.	3208.
	(	0.65)	(	1.46)	3.33)	5.29)	7.33)	20.32)	43.56)	67.00)	90.84)
HYDROGRAPH AT	3	0.17	1	118.	237.	355.	474.	711.	1185.	1777.	2370.
	(	0.44)	(	3.36)	6.71)	10.07)	13.42)	20.13)	33.55)	50.33)	67.11)
2 COMBINED	3	0.42	1	156.	327.	502.	677.	1221.	2723.	4143.	5578.
	(	1.09)	(	4.41)	9.26)	14.22)	19.18)	34.58)	77.12)	117.33)	157.94)
ROUTED TO	4	0.42	1	10.	78.	231.	551.	1102.	2471.	3789.	5106.
	(	1.09)	(	0.29)	2.22)	6.53)	15.61)	31.19)	69.97)	107.30)	144.60)

PLAN 1 .....

		INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION		114.48	114.50	118.50
STORAGE		29.	29.	54.
OUTFLOW		0.	0.	288.

RATIO OF PMF	MAXIMUM RESERVOIR U.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
0.05	115.73	0.00	35.	52.	0.00	16.00	0.00
0.10	116.71	0.00	42.	118.	0.00	15.92	0.00
0.15	117.51	0.00	47.	187.	0.00	15.92	0.00
0.20	118.22	0.00	52.	259.	0.00	15.92	0.00
0.30	118.97	0.47	58.	718.	0.58	15.75	0.00
0.50	119.49	0.99	62.	1538.	1.67	15.67	0.00
0.75	119.93	1.43	66.	2366.	4.50	15.67	0.00
1.00	120.31	1.81	70.	3208.	5.42	15.67	0.00

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

		INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION		97.20	97.20	98.90
STORAGE		142.	142.	191.
OUTFLOW		0.	0.	17.

RATIO OF PMF	MAXIMUM RESERVOIR U.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
0.05	98.21	0.00	171.	10.	0.00	21.25	0.00
0.10	98.95	0.05	193.	78.	4.67	18.25	0.00
0.15	99.01	0.11	195.	231.	7.58	16.25	0.00
0.20	99.11	0.21	197.	551.	9.17	15.75	0.00
0.30	99.23	0.33	201.	1102.	10.83	15.83	0.00
0.50	99.47	0.57	208.	2471.	12.08	15.75	0.00
0.75	99.66	0.76	214.	3789.	13.42	15.75	0.00
1.00	99.83	0.93	219.	5106.	14.67	15.75	0.00

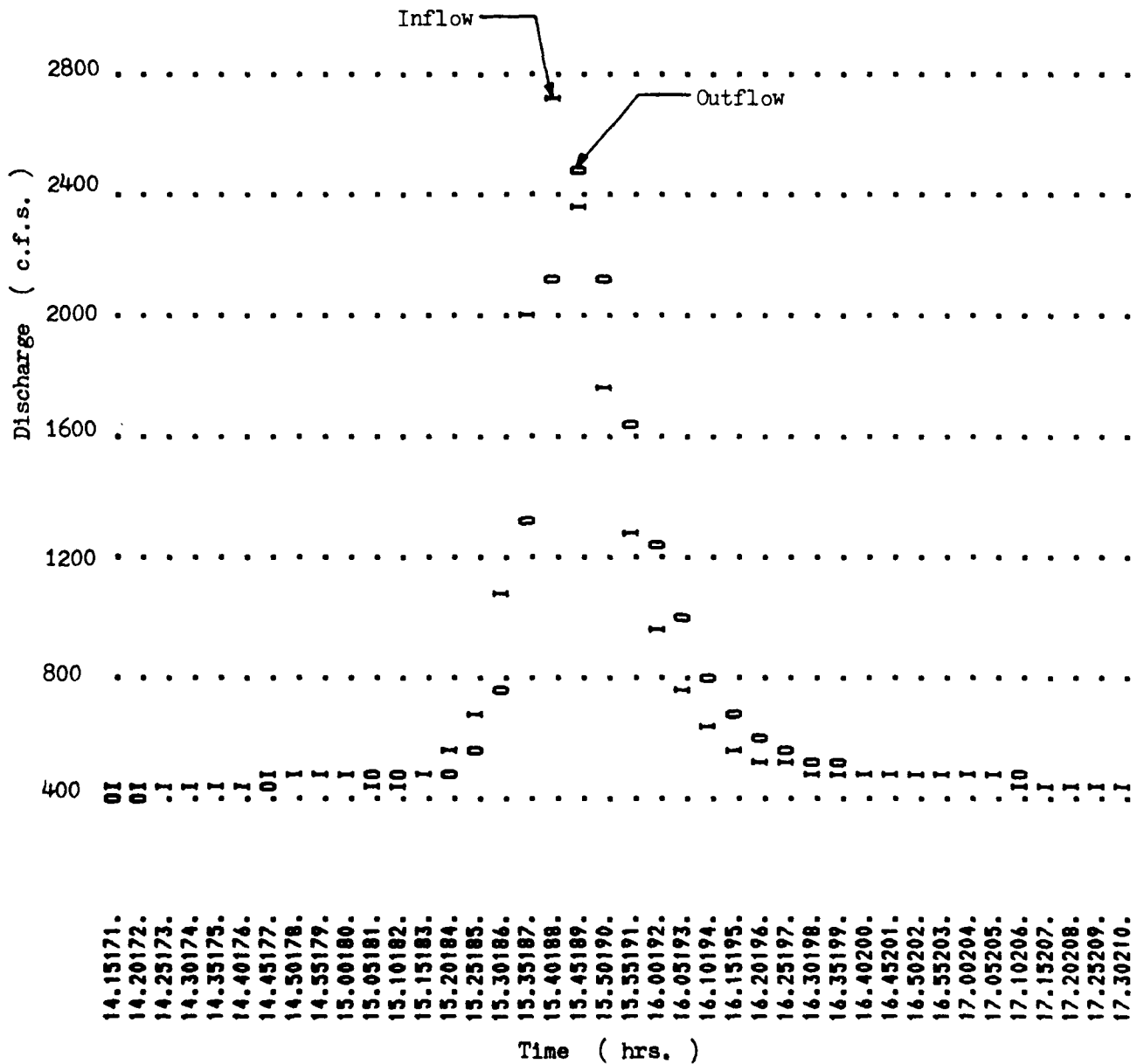
P.M.F. OUTPUT DATA

SHEET 7B APPENDIX C

INFLOW - OUTFLOW  
HYDROGRAPH  
FOR 50% P. M. F.

Max. Inflow = 2,715 c.f.s.

Max. Outflow = 2,477 c.f.s.



APPENDIX D

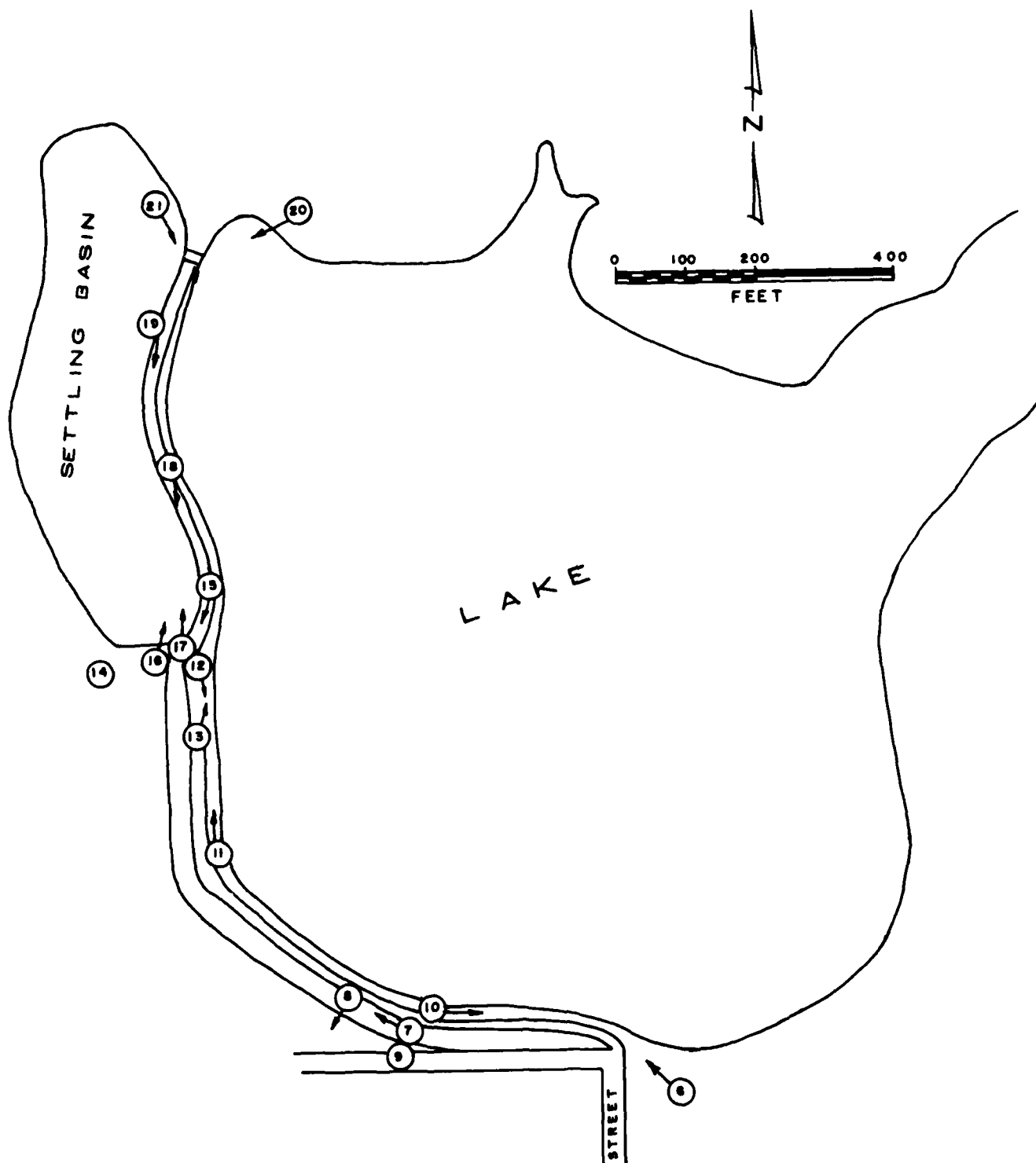


PHOTO INDEX  
LOCH LEONARD DAM  
CASS COUNTY, MO.

# LIST OF PHOTOGRAPHS

## Photo No.

1. Aerial Photo Looking South
2. Aerial Photo Looking North
3. Aerial Photo Looking Northeast
4. Aerial Photo Looking Southeast
5. Aerial Photo Looking West
6. Road onto Embankment at East Abutment
7. Downstream Face of Southwest Embankment
8. Seepage Area along Southwest Embankment
9. Seepage Area along Southwest Embankment in Ditchline of Road
10. Front Face of South Embankment
11. Front Face of West Embankment
12. Front Face of West Embankment
13. Pump Station in Lake
14. Pump Station in Creek
15. Downstream Face, West Embankment, at Lake Pump Station (Note Seepage at Toe Near Power Pole)
16. Embankment Between Settling Basin and Lake
17. View of Settling Basin Looking North
18. South Embankment of Settling Basin Showing Pump Discharge Pipe from Creek
19. Crest of Embankment Between Settling Basin and Lake
20. Front Face of Embankment Between Settling Basin
21. Pipe Between Lake and Settling Basin

